

Research Report

— 562 —

INTERPRETATION OF DYNAMIC PAVEMENT DEFLECTIONS

by

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ABSTRACT

In 1977, a methodology was developed to evaluate pavement performance using dynamic (Road Rater) deflections. Since then, additional research has resulted in modifications in the procedures. This paper presents the procedures presently used to evaluate flexible pavement structures. Background information is included on various procedures used by others. A sample set of data is presented and evaluated. A discussion is included on how the analyses of dynamic pavement deflections can be used to design overlays and in pavement management.

INTRODUCTION

In 1977, a methodology was developed to evaluate the behavior or performance of flexible pavements using dynamic (Road Rater) deflections (14). This method utilized deflections computed by elastic theory using the Chevron computer program (7, 15) to simulate Road Rater deflections. This methodology involved a series of graphical interpolations and required considerable engineering judgment. Modifications presented in this paper refine and simplify the procedure considerably.

Nondestructive tests of pavements have been empirically correlated with field strength tests. There has been considerable use of elastic theory and dynamic testing to estimate layer moduli. Equipment used has included the Benkelman beam, the California traveling deflectometer, a falling-weight deflectometer, the Dynaflect, the Road Rater, and other vibratory testers (8).

Of the various devices available for the nondestructive measurement of pavement deflections, the simplest and most commonly used is the Benkelman beam. The Benkelman beam uses a lever to measure the rebound deflection as the tires of a test vehicle of known weight roll past the tip or 'probe' of the beam (29). The beam has been successfully mechanized, making it possible to measure deflections continuously under a moving axleload. The California traveling deflectometer is one device utilizing the principle (8, 29).

Benkelman beam deflections can be used to evaluate pavement performance; such analyses have been incorporated into overlay

design procedures (12, 29). Benkelman beam deflections have also been correlated with Road Rater deflections (16).

The second generation of measurement devices are the vibratory and (or) impact testers. Included in this group are the Dynaflect, the Road Rater, the WES 72.6- and 40.1-kN (16- and 9-kip) vibrators, and the Shell 18.1-kN (4-kip) vibrator (8). In general, vibratory testers induce a steady-state sinusoidal vibration in the pavement with a dynamic force generator. The magnitude of the dynamic force and the means by which the force is generated are the primary differences among vibratory testers. An impact device (the falling-weight deflectometer) measures the surface deflection resulting when a known weight is dropped a specified distance (8).

Deflection bowls have been used to study pavement response characteristics (3, 5, 6, 10, 11, 25). Both empirical and theoretical analyses utilizing elastic theory have been considered. Factors considered in the evaluation of the deflection bowls, such as defined by dynaflect data, are maximum deflection, spreadability, surface curvature index, base curvature index, and the fifth sensor deflection. Spreadability, defined as the average deflection for all five Dynaflect sensors expressed as a percentage of the maximum deflection, is a measure of the ability of the pavement structure to distribute the load. The surface curvature index is the difference in deflections at the first and second sensors. It is a measure of the condition of the upper layers of the pavement structure. The base curvature index is the difference between the deflections at the fourth and fifth

sensors and is meant to be an indication of the condition of the lower layers. Normally, the maximum deflection is an indicator of the condition of the bound layers while the deflection at the fifth sensor is an indicator of subgrade adequacy (3, 5, 6, 10, 11, 25).

The falling-weight deflectometer also has been used to study pavement behavior. Procedures have been developed which incorporate falling-weight data into overlay designs for flexible pavements (4).

Kentucky research has used Road Rater deflections since 1972. Other organizations have used Road Rater deflections to evaluate the structural condition of flexible pavements (1, 9). Procedures presented in this paper have evolved from several earlier studies (14, 15, 18, 19, 22, 23) and represent those currently used in Kentucky. Research is continuing to further refine the evaluation process.

SIMULATION OF ROAD RATER DEFLECTIONS

Characteristics of the Road Rater

The testing head of the Kentucky Road Rater consists of a vibrating mass weighing 72.6 kg (160 pounds) which impulses the pavement. The test head is lowered to the pavement until the hydraulic pressure of 4.82 MPa (700 psi) produces a static load of 7.428 kN (1,670 pounds). The mass is vibrated using preselected frequencies of 10, 20, 25, and 40 Hz. The forced motion of the pavement is measured by velocity sensors normally located at 0 mm (0 feet), 305 mm (1 foot), 610 mm (2 feet), and 914 mm (3 feet) from the center of the test head.

Vibrating the mass at a frequency of 25 Hz and an amplitude of 1.524 mm (0.06 inch) results in a peak-to-peak dynamic force of 2.668 kN (600 pounds). Once the dynamic force is set for a given frequency and amplitude, the other preset frequencies will vary the amplitude of the vibrating mass such that the dynamic force remains fixed. The composite loading consists of a dynamic force of 2.668 kN (600 pounds) amplitude oscillating about the static load of 7.428 kN (1,670 pounds).

Superposition Principles

The Road Rater loading is transmitted to the pavement by two 'feet' symmetrically located on either side of a beam extending ahead and carrying the sensors. Superpositioning is applicable provided the deformations are small and do not substantially affect the action of external forces. A linear relationship between displacement and external force must exist or be assumed to exist (24). Applying superposition principles to the Road

Rater, the deflection resulting from the load applied to one 'foot' is added to the deflection due to the load applied by the other 'foot'. For the symmetrical conditions of the Road Rater, deflection calculations only need be made for one 'foot' and the radii corresponding to each sensor location.

The dynamic loading (sine wave) of the Road Rater can be approximated by a square wave such that its amplitude is $1/2$ times the amplitude of the sine wave. The maximum and minimum loadings of the square wave are 8.37 kN (1,882 pounds) and 6.49 kN (1,458 pounds). From symmetry, the loads on each 'foot' of the test head are equal to 4.186 kN (941 pounds) and 3.243 kN (729 pounds). The dynamic deflection is defined by $D(\text{total}) = (D(4.19) - D(3.24)) \times 2$, in which $D(4.19)$ and $D(3.24)$ represent the deflections calculated by the Chevron computer program for the maximum and minimum loading conditions on one 'foot'.

Input Parameters for the Chevron Computer Program

In addition to load, required inputs to the Chevron program include a contact pressure corresponding to the load; the number of layers; and the thickness, Young's modulus, and Poisson's ratio for each layer. The contact pressure of the maximum and minimum loads are varied to maintain a constant area (102 by 178 mm (4 by 7 inches)) for each 'foot'. The following constants were used to calculate simulated Road Rater deflections (22):

Poisson's Ratio: Asphaltic Concrete -- $\mu = 0.40$

Granular Base -- $\mu = 0.40$

Subgrade -- $\mu = 0.45$

Load = 4.186 kN (941 pounds): Contact Pressure = 0.231 MPa
(33.5 psi)

Load = 3.243 kN (729 pounds): Contact Pressure = 0.183 MPa
(26.5 psi)

A matrix of asphaltic concrete (AC) thicknesses and moduli, dense-graded aggregate (DGA) thicknesses, and the constants indicated above were used as input. Simulated deflections were calculated using elastic theory; these deflections were used to develop theoretical relationships presented in this paper (14, 15).

Moduli of granular bases (E2) are a function of the moduli of the confining layers of asphaltic concrete (E1) and subgrade (E3). The modulus of the crushed stone layer is estimated from the relationship $E2 = F \times E3$, in which there is an inverse linear relationship between F and $\log E3$. The ratio of the modulus of the base to the modulus of the subgrade is equal to 2.8 at a California bearing ratio (CBR) of 7 and is equal to 1.0 when E1 equals E3 (i.e., $E1 = E2 = E3$ -- the case of a Boussinesq semi-infinite half-space) (22). Subgrade moduli in psi may be approximated by the product of the CBR and 1,500. This method of estimating base moduli appears adequate for normal design considerations up to a CBR of about 18 (2, 14, 27, 28).

Reference Conditions

The modulus of elasticity of asphaltic concrete varies as a function of frequency of loading and temperature. Conditions for the current Kentucky thickness design procedures and the method for conducting Benkelman beam tests correspond to a modulus of

3.31 GPa (480 ksi) at 0.5 Hz and a pavement temperature of 21.1 C (70 F). The reference frequency for the Road Rater was selected at 25 Hz, and the corresponding asphaltic concrete modulus at 21.1 C (70 F) is 8.27 GPa (1,200 ksi) (19, 20, 21).

Because of the significant effects of temperature on modulus of elasticity of asphaltic concretes, a system was developed to adjust deflection measurements to a reference temperature and modulus. The adjustment scheme used ratios of deflections at reference conditions to deflections resulting from arrayed variables of layer thicknesses and moduli (14, 15, 16, 18, 20, 21).

EVALUATION OF THE PAVEMENT STRUCTURE

Foundation (subgrade) stiffness is a factor affecting the behavior of a pavement structure. Variations in subgrade support occur mainly as a result of variations in moisture contents and in soil types. A significant decrease in subgrade stiffness (or modulus of elasticity) will result in a loss of ability to support the pavement structure adequately and will lead to increased distress in the layers of the structure. Signs of distress include rutting, increased roughness, and cracking (29).

Estimates of subgrade strength are necessary to evaluate overall pavement conditions. A 'design' condition exists when there is no loss of 'effective' thickness in any of the layers. A knowledge of as-built (design) thicknesses of layers is necessary before an evaluation of the pavement structure can be made. Those thicknesses should be available from construction and (or) maintenance records; cores also may be obtained to determine or verify layer thicknesses. Generally, conditions involve deterioration in the layers of the structure. This means that the individual layers are behaving similar to another combination of layer thicknesses composed of new-quality materials; that is, the structure is behaving as an 'effective' structure. In such a case, it is necessary to estimate the 'effective' thicknesses of the deteriorated structure.

DESCRIBING THE SHAPE OF THE DEFLECTION BOWL

The analysis of deflections involves the shape of the deflection bowl (3, 5, 6, 10 - 12, 14, 15, 23 - 26). The No. 1 projected deflection, an empirical evaluation of Road Rater deflection data (14 - 16, 23), is obtained by extrapolating a straight line through the deflection values of the No. 2 and No. 3 Sensors when log deflection is plotted as a function of the arithmetic distance from the load head. The deflection at the position corresponding to the No. 1 Sensor is the No. 1 projected deflection (Figure 1):

$$\begin{aligned} \text{No. 1 projected} = & \exp[(2 \log \text{No. 2 deflection}) \\ & - (\log \text{No. 3 deflection})]. \end{aligned}$$

The slope of the semi-log line (secant line), the difference in magnitude between the No. 1 projected and the No. 1 Sensor deflections, and the magnitude of all deflections are indicative of the shape of the deflection bowl.

For a given pavement structure, asphaltic concrete modulus, and subgrade modulus, there is a difference between the No. 1 projected and the No. 1 Sensor deflections for theoretical deflections (Figure 1). Similarly, there is also a difference between these values for field-measured deflections. Normally, the differences between the No. 1 projected deflection and the No. 1 Sensor deflection for both theory and field measurements are the same. Slab deterioration is indicated when field measurements indicate a No. 1 Sensor deflection greater than the No. 1 projected deflection (Figure 2) and the difference between these values is greater than the difference for theoretical deflections. A foundation problem, or lack of supporting capability, may be

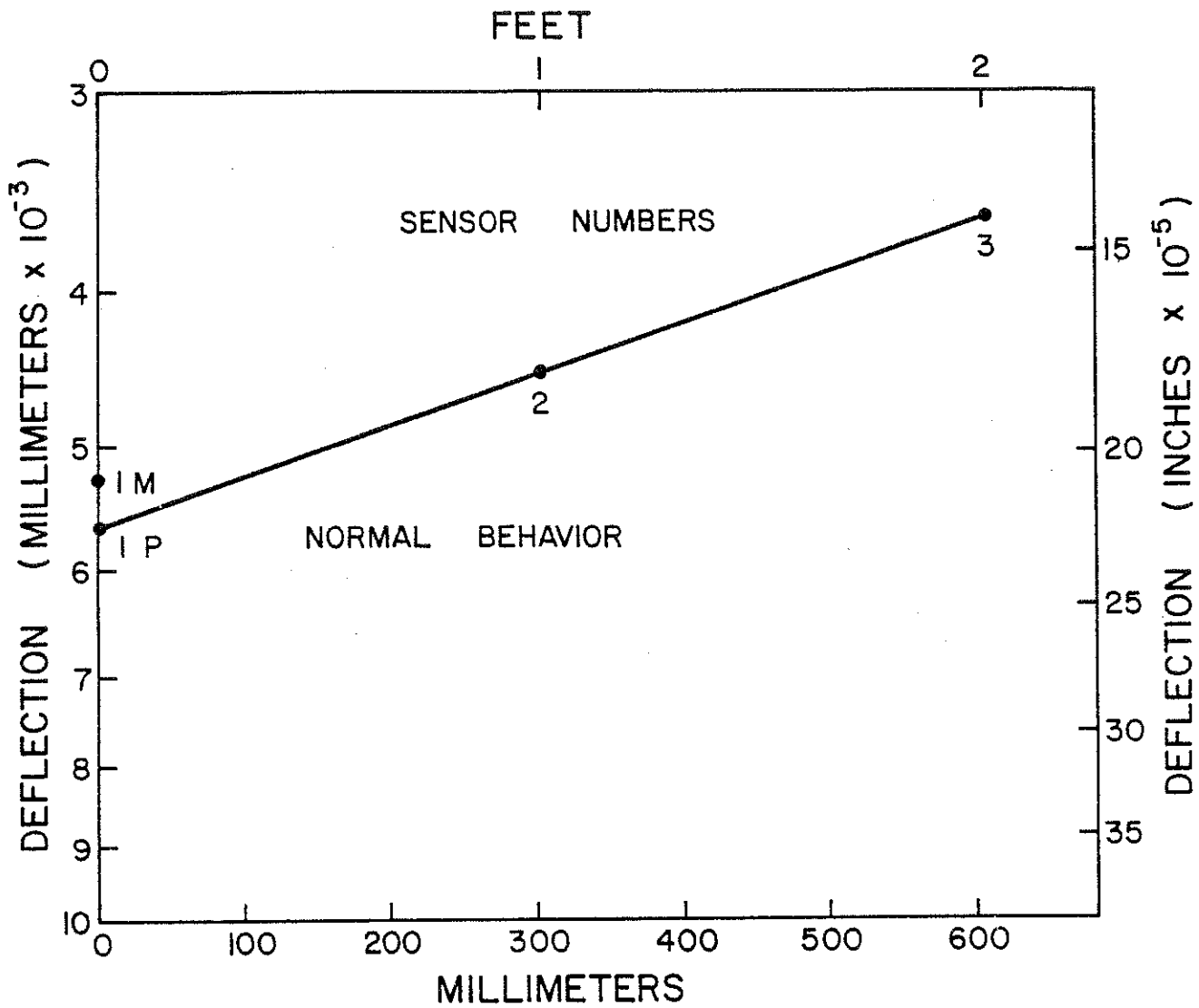


Figure 1. Deflection versus Distance from Load Head and Determination of No. 1 Projected Deflection: Example Difference between No. 1 Sensor Deflection (1M) and No. 1 Projected Deflection (1P) for Normal Pavement Behavior (14, 15).

indicated by increased magnitudes of all field deflections and a No. 1 projected deflection greater than the No. 1 Sensor deflection (Figure 3). Also, the difference between the No. 1 projected deflection and the No. 1 Sensor deflection for field measurements should be greater than the difference for theoretical deflections.

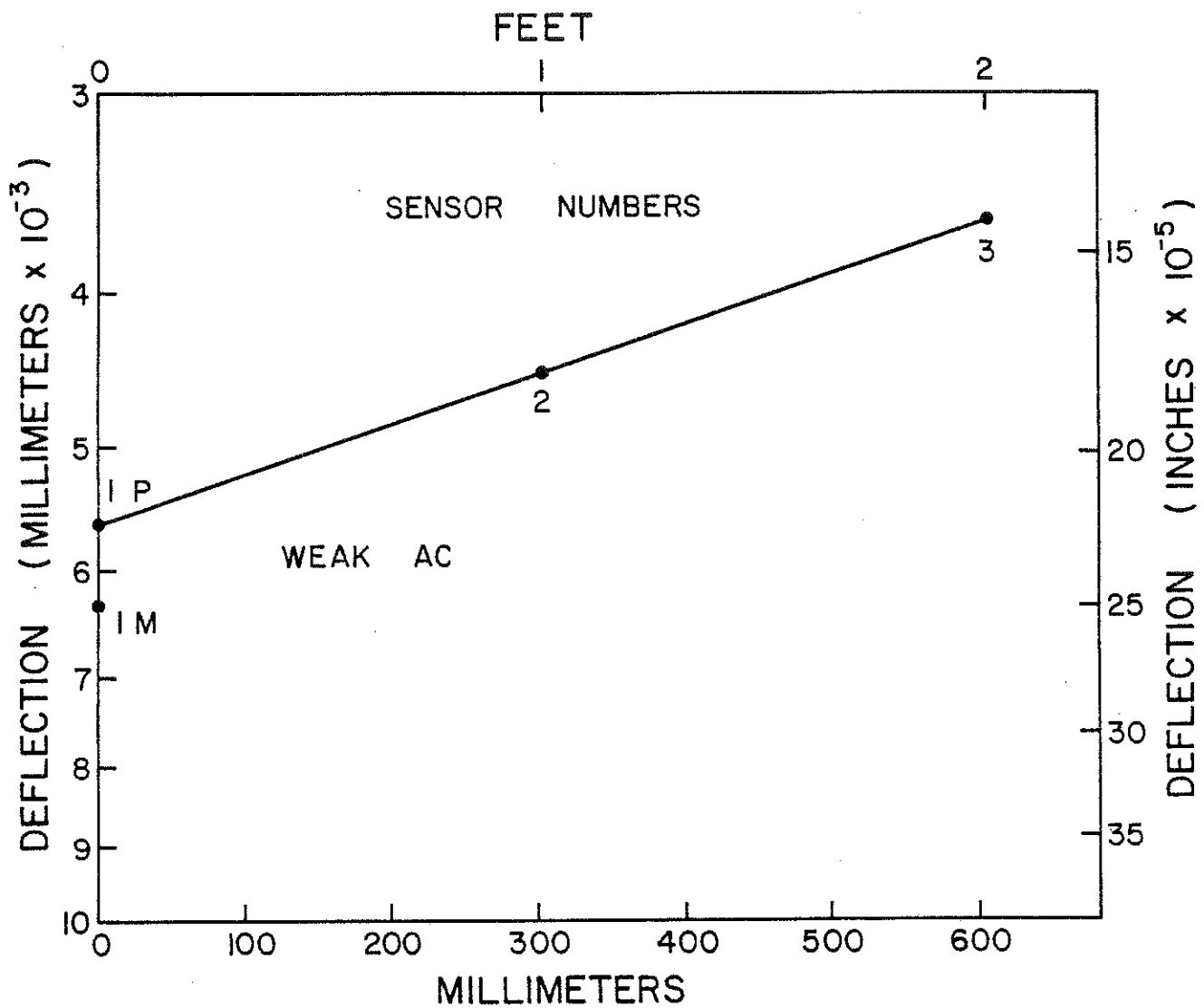


Figure 2. Deflection versus Distance from Load Head and Determination of No. 1 Projected Deflection: Example Difference between No. 1 Sensor Deflection (1M) and No. 1 Projected Deflection (1P) for a Pavement with a Weak Asphaltic Concrete Layer (14, 15).

A plot of No. 1 projected deflections versus No. 1 Sensor deflections in log-log form may be used to identify variations in pavement structure. The solid lines in Figure 4 show the theoretical relationship between No. 1 projected and No. 1 Sensor deflections for a constant structure and asphaltic concrete modulus. Subgrade modulus varies along the line. Points about the line represent field-measured deflections. The two dashed

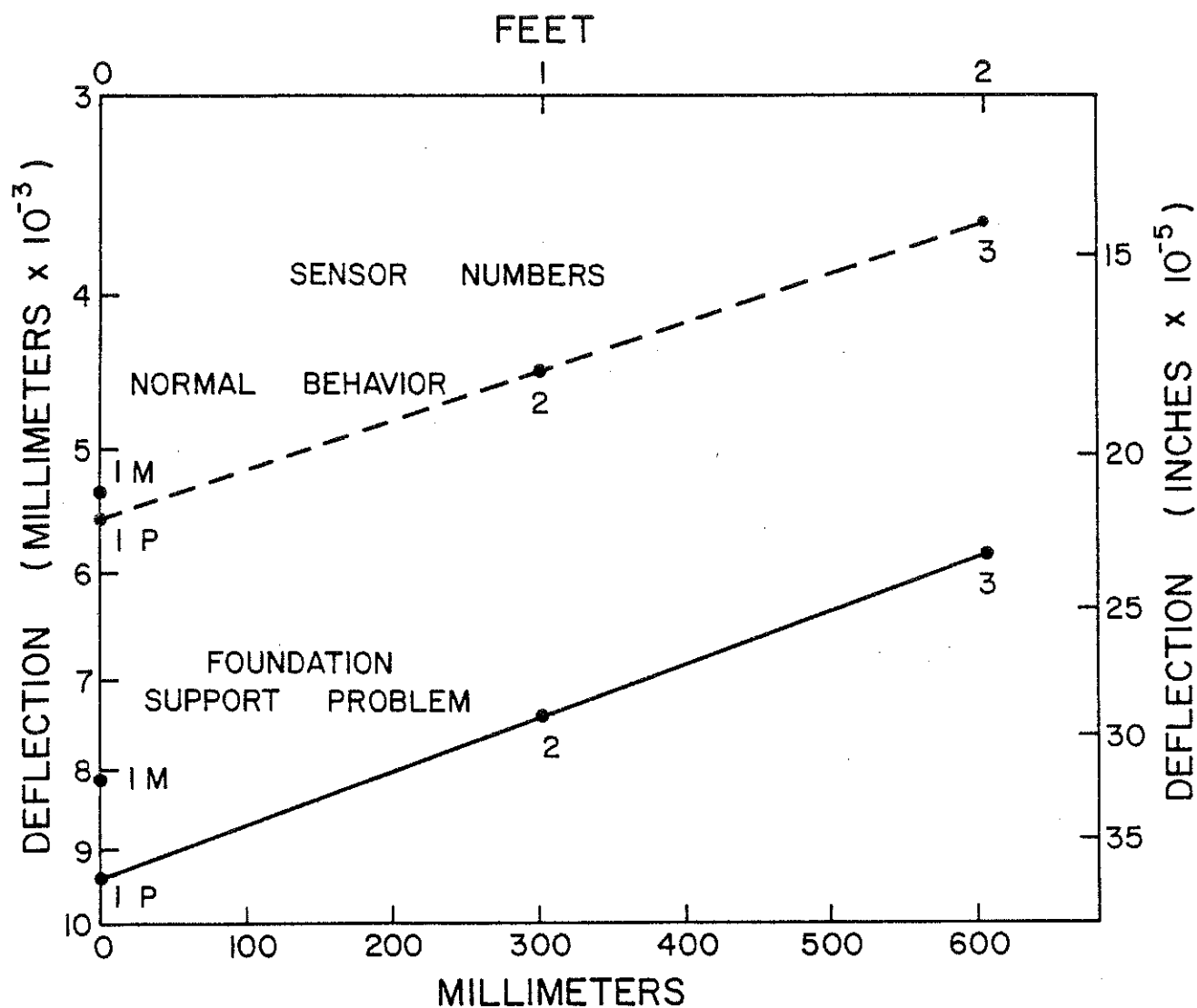


Figure 3. Deflection versus Distance from Load Head and Determination of No. 1 Projected Deflection: Example Difference between No. 1 Sensor Deflection (1M) and No. 1 Projected Deflection (1P) for a Pavement with a Foundation Support Problem (14, 15).

lines indicate the variation in position of the theoretical line due to changes in the magnitudes of the deflections by \pm one unit (2.54×10^{-4} mm or 1×10^{-5} inch) on the Road Rater meters and the associated change in calculated No. 1 projected deflection. The zone inside these lines represents a normal variation due to reading the meters of the Road Rater.

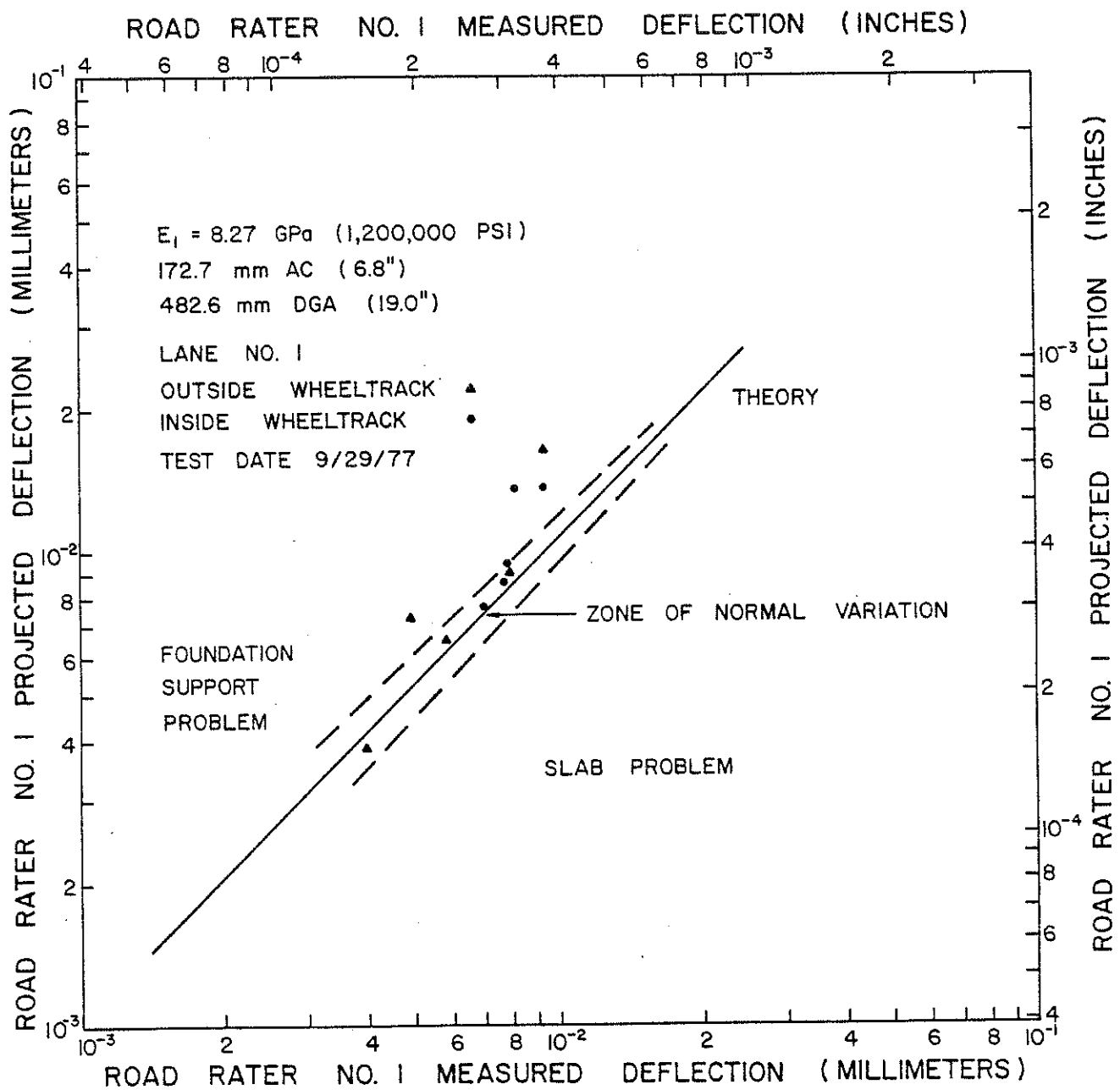


Figure 4. Relationship between Road Rater No. 1 Projected Deflection and Road Rater No. 1 Sensor Deflection; Field Measurements Indicate a Foundation Support Problem (14, 15).

ESTIMATING SUBGRADE STRENGTH

Knowing layer thicknesses, relationships were developed (from elastic theory) between theoretical deflections and subgrade moduli for a constant (reference) asphaltic concrete modulus of elasticity (Figure 5). For a given pavement structure, Road Rater deflections adjusted to a constant (reference) modulus of asphaltic concrete and associated temperature may be used as input. For each field deflection, there is a corresponding predicted value of the subgrade modulus (14, 15, 23).

The methodology for estimating subgrade strength has evolved through several stages. Initially, the first three sensor deflections were used to obtain three estimates of the subgrade modulus. The methodology was simplified so only the No. 2 Sensor deflection was used (14, 15, 23). Further refinements in the procedure utilize the No. 2 and No. 3 deflections to compute a No. 1 projected deflection (14 - 16, 23). The No. 1 Sensor deflections and No. 1 projected deflections are then plotted and compared to values predicted by elastic theory.

Interpretation of Deflection Data

Foundation or Subgrade Problems -- When a foundation or subgrade problem exists, the deflection bowl is much 'broader' and 'flatter' than would be theoretically expected, and the magnitudes of all the measured deflections are greater than those predicted by elastic theory (Figures 1 - 3). Limited test data have indicated that excessive moisture in the subgrade could result in a measured deflection bowl of this shape (9, 14, 15, 23). In areas where there were suspected problems with the subgrade and

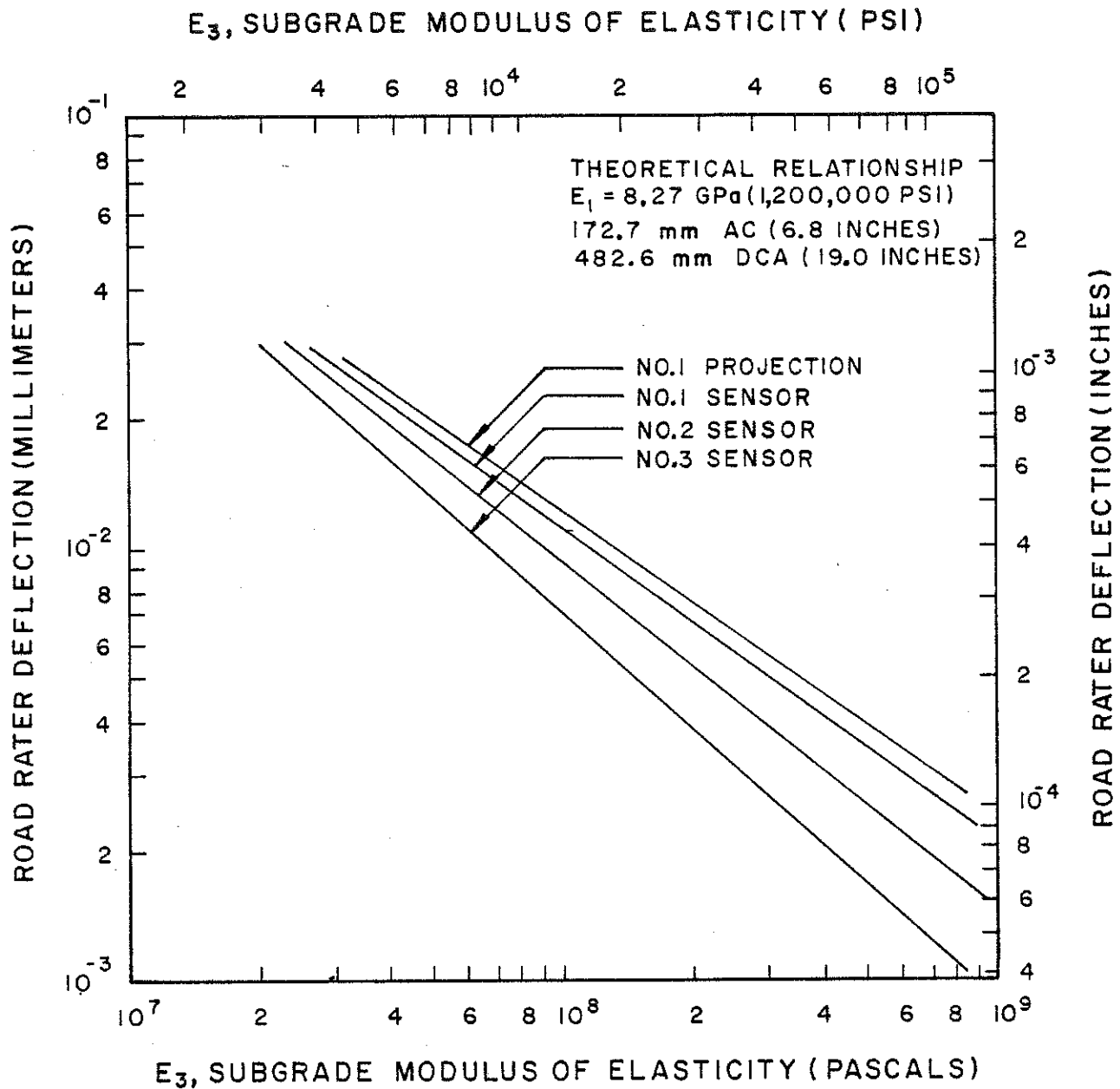


Figure 5. Theoretical Relationships: Road Rater versus Subgrade Modulus of Elasticity for a Constant Structure and Asphaltic Concrete Modulus. (Note: This figure represents a minor revision in Figure 1 of Reference 14 and Figure 6 of Reference 15.)

supporting (unbound) layers, tests indicated there was more variability among the No. 2 and No. 3 deflections than among the measured No. 1 deflections. In such a situation, either the No. 2

or No. 3 Sensor deflections, or both, and the associated No. 1 Projected deflections are not matching elastic theory (Figures 3 and 6).

Bound Layer Problems -- Conversely, if there is a deficiency in the bound layer (asphaltic concrete), the deflection bowl bends sharply about the point of application of the load (Figures 1 - 3). The measured No. 1 Sensor deflection is considerably greater than its theoretical counterpart while the No. 2 and No. 3 deflections very closely match predictions from elastic theory (Figure 2). This condition can also be illustrated by the plot of No. 1 projected deflection versus No. 1 Sensor deflections (Figure 6). Deflection bowls of this shape are usually observed where there are visible signs of pavement distress such as cracking and rutting (9, 14, 15, 23).

Quantifying Effective Behavior -- Measured Road Rater deflection bowls can be evaluated using theoretical relationships. Pavement behavior (or condition) can be given in terms of a predicted subgrade modulus, effective layer thicknesses, and effective moduli of the layers. The effective behavior may be expressed as any combination of these variables which matches the measured deflections. In this paper, pavement behavior is expressed in terms of a predicted subgrade modulus and an effective thickness of 'reference' new-quality materials.

Obviously, some combinations of subgrade modulus, effective thicknesses, and layer moduli are not acceptable. An example of an unacceptable representation of pavement behavior would be an extremely low (weak) predicted value of subgrade modulus and an effective thickness of the reference material greater (thicker)

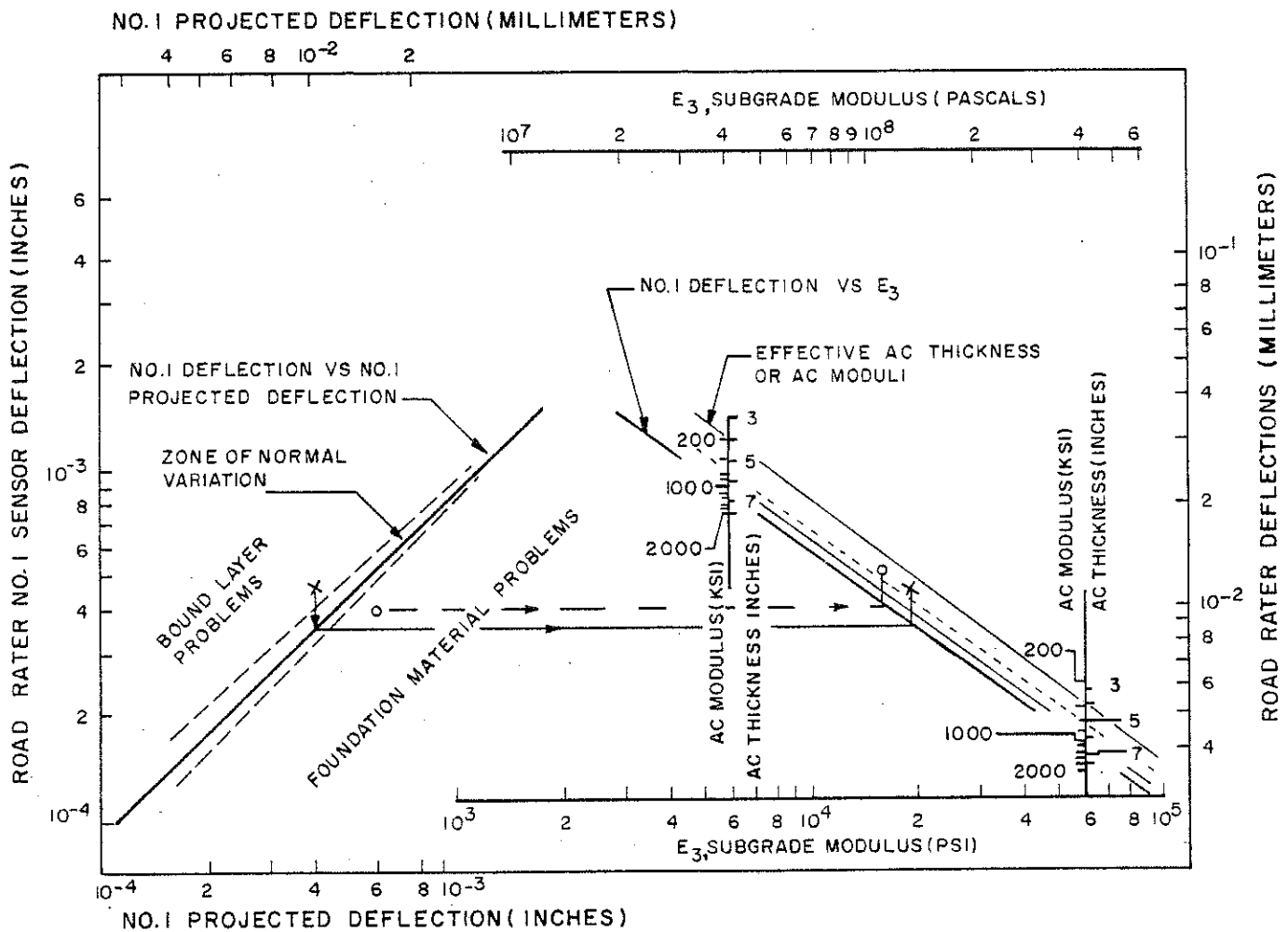


Figure 6. Combined Plot of No. 1 Deflection versus No. 1 Projected Deflection versus Subgrade Modulus Illustrating a Method for Estimating Subgrade Strength and Effective Behavior.

than the design or as-constructed layer thicknesses. While this combination of parameters might result in a deflection bowl which resembles the measured bowl, it would not be logical for use in designing overlays because a negative calculated overlay might result. An alternative expression of pavement performance would be an increased predicted subgrade modulus and a reduced effective thickness of the reference material. Expressions of pavement behavior using asphaltic concrete moduli of elasticity other than the reference upon which the flexible pavement design curves used

in Kentucky are based also would not be usable. These same curves are used in designing overlays (2, 14 - 16, 19, 22, 23).

Determining the 'true' effective structure of an existing pavement is an iterative process. If the quality of the asphaltic concrete is held fixed at some reference value, there are a number of combinations of predicted subgrade moduli and effective layer thicknesses which will match the measured deflection bowl. The magnitudes of the measured deflections and the constructed layer thicknesses determine the reasonableness of the combinations. The iterative process involves selecting a subgrade modulus and effective thicknesses and comparing the resulting theoretical deflection bowl to the measured bowl. If the theoretical bowl does not match the measured deflection bowl, the subgrade modulus and effective thicknesses are varied. This process is continued until a satisfactory match is obtained.

Figure 6 illustrates a procedure which usually eliminates the need for a series of iterations. The methodology utilizes the theoretical relationship of No. 1 projected deflections versus No. 1 Sensor deflections and the theoretical relationship between subgrade modulus of elasticity and No. 1 Sensor deflections.

In Figure 6, the lines on the left represent a theoretical relationship between No. 1 Sensor deflections and No. 1 projected deflections. The dashed lines represent normal operator variation in reading meter scales. The solid line on the right is the theoretical relationship between Road Rater No. 1 Sensor deflections and subgrade moduli. Two different points are shown in Figure 6. The "x's" are data points which would be suspected of having problems in the bound layers (from the No. 1 deflection

versus No. 1 projected deflection relationship). The "o's" represent points suspected of having foundation or subgrade problems.

The "x" points (Figure 6) have a No. 1 Sensor deflection higher than would be predicted from the given values of the No. 2 and No. 3 deflections and the corresponding No. 1 projected deflections. Thus, it is necessary to adjust the deflection to match the deflections at the No. 2 and No. 3 Sensors. The adjusted No. 1 deflection is then used to predict the subgrade modulus to compare to the theoretical relationship of Road Rater No. 1 deflection versus subgrade modulus. The point will plot above the theoretical line, indicating behavior weaker than the reference conditions. The behavior may be expressed either in terms of reduced asphaltic concrete modulus or as a reduced thickness of asphaltic concrete. For overlay designs, effective behavior is more meaningful when expressed as a reduced thickness.

The "o" points (Figure 6) have a No. 1 deflection lower than expected from the measured deflections at the No. 2 and No. 3 Sensors and the associated No. 1 projected deflections. The deflection bowl is very 'broad' and 'flat' (Figure 3) and representative of a problem in the subgrade or supporting layers. To represent the observed pavement performance in terms of a predicted subgrade modulus and effective thickness of asphaltic concrete of reference, new-quality material, it is necessary to use the No. 1 sensor deflection to predict the subgrade modulus. The theoretical relationship of No. 1 projected deflection versus No. 1 Sensor deflection is used in combination with the measured No. 1 deflection to determine an adjusted No. 1 deflection. The

adjusted value will have a greater magnitude than the measured No. 1 deflection and will be compatible with the measured No. 2 and No. 3 deflections and the associated No. 1 projected deflection. When the predicted subgrade strength (based on the No. 1 Sensor deflection) is plotted versus the adjusted No. 1 deflection, the expression of pavement behavior is in terms of a predicted subgrade strength and a reduced thickness of new-quality material.

Analyses of field deflections indicated this procedure will produce results which can be used as input into an overlay design process. Road Rater testing of pavements before and after overlaying shows that the ultimate behavior of the overlaid pavement is equal to that of a pavement having a total thickness of new-quality material equal to the sum of the effective thickness before overlaying and the overlay thickness (14, 15, 23).

Subgrade moduli may be estimated using deflections measured by any of the sensors singly or in combination, and these moduli may vary slightly. These variations usually are not significant because, for a constant asphaltic concrete modulus and any given measured deflection bowl, there is a range of subgrade moduli and asphaltic concrete thicknesses which are representative of the measured deflections. If the measured deflection bowl and the theoretical bowl were identical, the same subgrade moduli would be predicted regardless of the way the deflections are manipulated.

Estimation of Effective Structure

The determination of the effective pavement structure is illustrated by the right side of Figure 6. If the pavement is

behaving as one having a thickness equal to or greater than the theoretical or 'design' thickness of asphaltic concrete, the field data will plot on the theoretical line. This also may be expressed in terms of the modulus of the asphaltic concrete -- if the pavement is behaving as one having a modulus of elasticity of the asphaltic concrete equal to or stronger than that of the reference material, the field data will plot on the theoretical line. If the field data plot above the line, the pavement is performing as one made of the reference materials which is thinner than the design or theoretical thickness. Alternatively, the pavement's performance could be given in terms of a pavement of the design thickness but having a modulus of elasticity of the asphaltic concrete weaker than the reference material.

When pavement behavior is expressed in terms of reduced layer thicknesses, all layers may be varied in any combination of thicknesses of reference materials and a predicted subgrade modulus that result in a deflection bowl which best matches the measured deflection bowl. The present procedure, however, maintains a constant crushed stone (DGA) thickness and expresses pavement behavior as a reduced thickness of asphaltic concrete at the reference modulus. If this method is used, lines of reduced thicknesses of asphaltic concrete can be superimposed onto the plot of subgrade modulus versus No. 1 Sensor deflection. The effective thickness may be interpolated from these lines (Figure 6).

Statistical analyses can be applied to either the measured No. 1 Sensor deflections, the predicted subgrade moduli, or the interpolated effective thicknesses. It is recommended that any

representation of pavement behavior encompass 90 percent of the data. Other investigators have selected similar levels (1, 5, 6). For example, If an effective structure is desired which encompasses 90 percent of the deflection data, the recommended effective thicknesses are equal to the mean effective thickness less the product of 1.2816 and the standard deviation. Figure 7 illustrates the selection of the multiplier for the standard deviation. Note that the multiplier 1.2816 corresponds to an

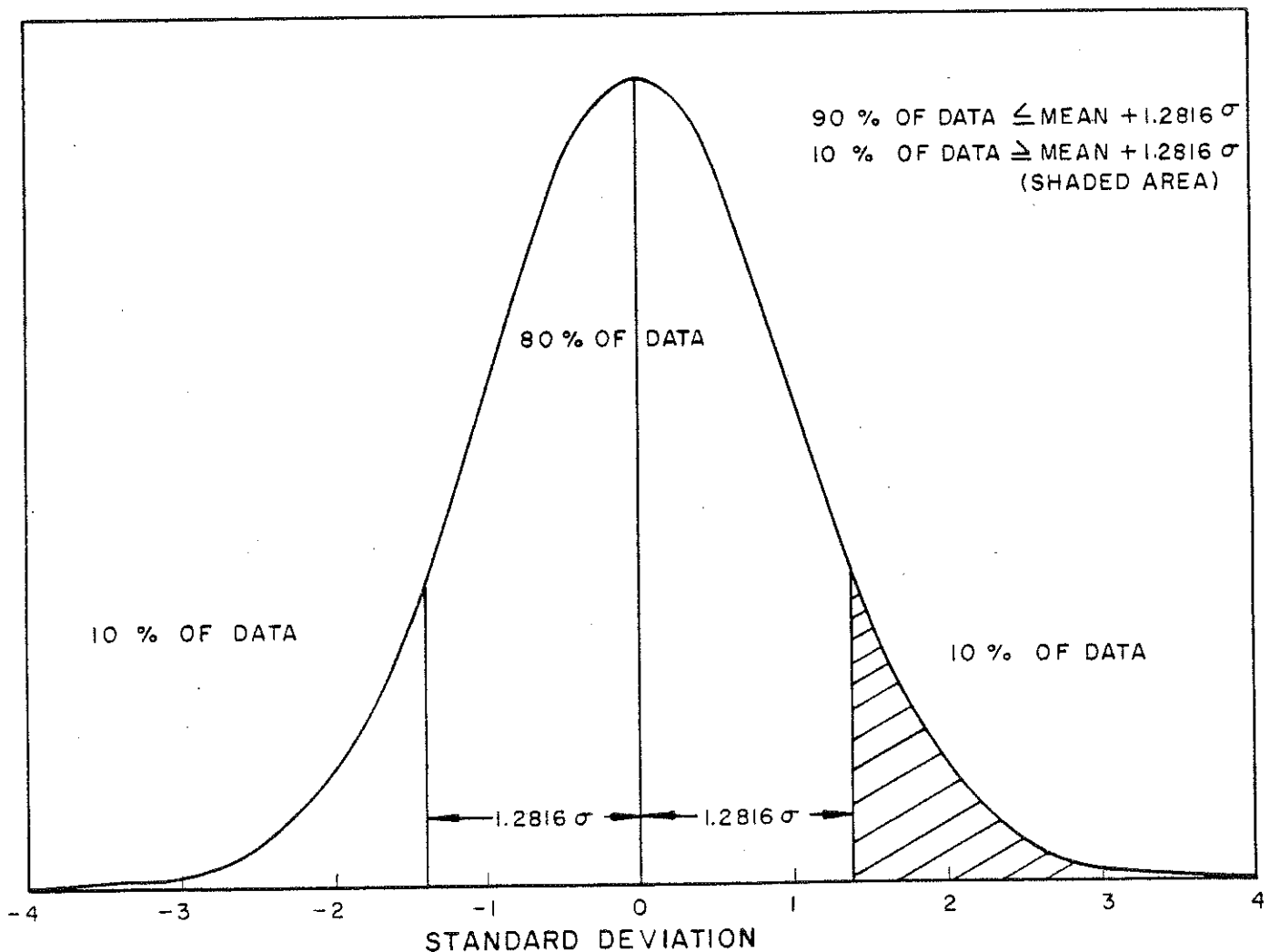


Figure 7. Illustration of 90th-Percentile Deflection: Theoretically, 90 Percent of the Measured Deflections Will Be Less than the Mean Deflection plus 1.2816 Times the Standard Deviation.

80-percent cumulative distribution but results in a 90th-percentile effective thickness because one tail of the normal distribution is not included (13, 17).

Example Analysis of Road Rater Data

Tables 1 and 2 and Figure 8 present a set of Road Rater measurements and illustrate the procedure to evaluate the data. This procedure utilizes concepts discussed in this paper and represent modifications in earlier procedures (14, 15, 23).

TABLE 1. ADJUSTED ROAD RATER DEFLECTION DATA
AND PREDICTIONS OF SUBGRADE MODULUS

US 60, BOYD COUNTY, KENTUCKY
EASTBOUND SHOULDER LANE
STATION 399+50 to 425+68
TEST DATE: 9/27/77
CORE THICKNESS:
172.7 mm. (6.8 in.) Asphaltic Concrete
482.6 mm. (19.0 in.) Dense Graded Aggregate
ADJUSTMENT FACTOR = 0.905
(TO ADJUST TO 70 F MEAN PAVEMENT TEMPERATURE)

ADJUSTED MEASURED DEFLECTIONS MILLIMETERS				PREDICTED SUBGRADE MODULUS MPa
No. 1	No. 2	No. 3	No. 1P	
0.00782	0.00505	0.00277	0.00927	160
0.00759	0.00528	0.00300	0.00935	167
0.00483	0.00345	0.00160	0.00739	303
0.00805	0.00691	0.00345	0.01380	155
0.00391	0.00254	0.00160	0.00396	455
0.00691	0.00460	0.00277	0.00767	186
0.00574	0.00391	0.00231	0.00665	245
0.00919	0.00691	0.00345	0.01330	128
0.00919	0.00874	0.00460	0.01660	128
0.00759	0.00620	0.00434	0.00881	167

NOTE: 1 in. = 25.4 mm
1 psi = 6,894.757 Pa

TABLE 2: CALCULATION OF EFFECTIVE (BEHAVIORAL) THICKNESS

US 60, BOYD COUNTY, KENTUCKY

EASTBOUND SHOULDER LANE

STATION 399+50 to 425+68

CORE THICKNESS: 172.7 mm. (6.8 in.) Asphaltic Concrete
482.6 mm. (19.0 in.) Dense Graded Aggregate

TEST DATE: 9/29/77

1. Read the effective structure for each data point from the plot of deflection versus subgrade modulus. Dense Graded Aggregate thickness remains constant (482.6 mm).

EFFECTIVE ASPHALTIC CONCRETE THICKNESS
MILLIMETERS

165.1
152.4
76.2
121.9
152.4
172.7
165.1
88.9
81.3
167.6

Mean 134.4
Standard Deviation 40.9

2. Mean Effective Structure
134.4 mm. Asphaltic Concrete
482.6 mm. Dense Graded Aggregate

3. Effective Structure Encompassing 90 % of the Data

1.2816 x standard deviation = 1.2816 x 40.9 mm.
= 52.4 mm. Asphaltic Concrete

Mean - (1.2816 x standard deviation) =
134.4 mm. - 52.4 mm. = 82.0 mm. Asphaltic Concrete

Effective Structure
82.0 mm. Asphaltic Concrete
482.6 mm. Dense Graded Aggregate

NOTE: 1 in. = 25.4 mm.

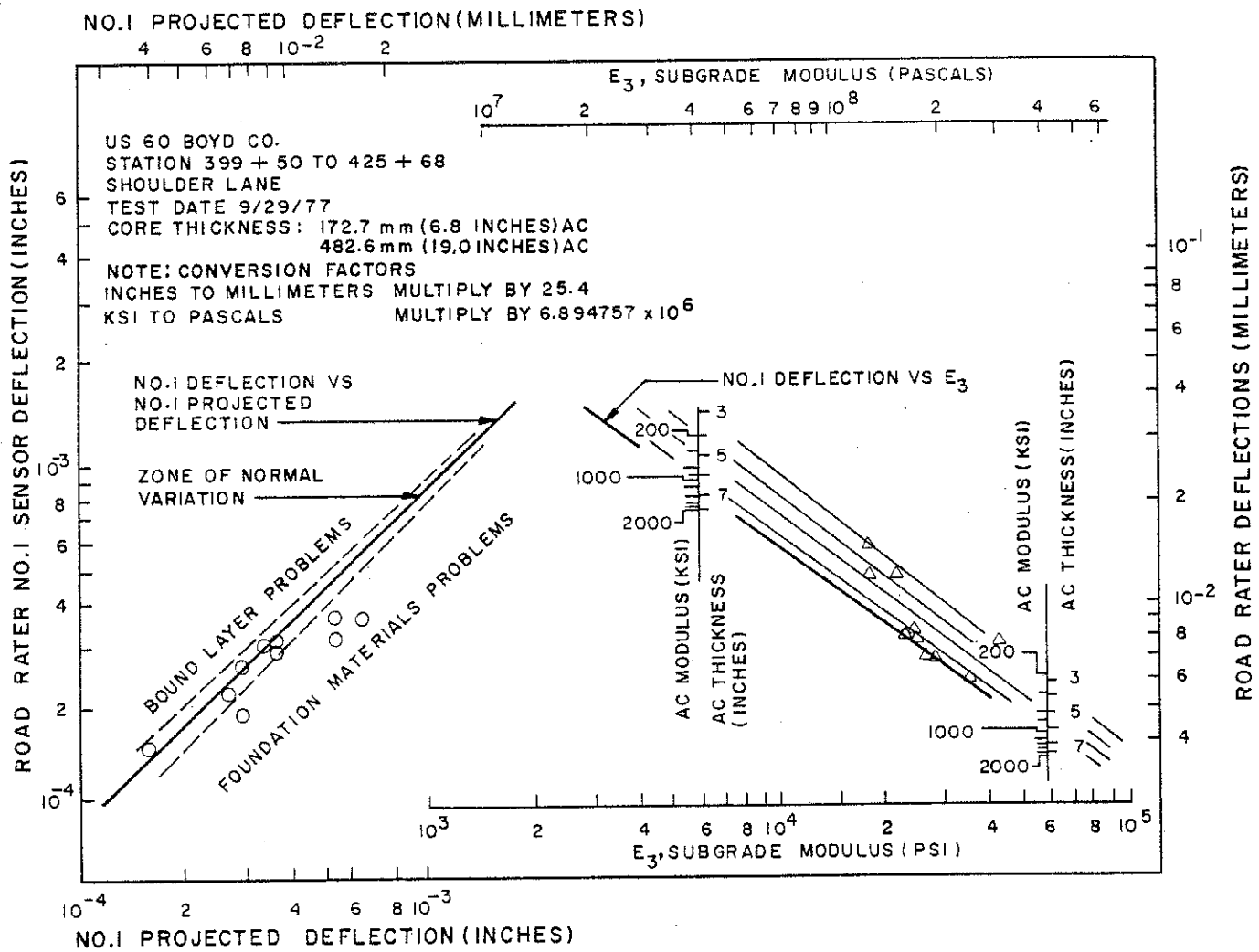


Figure 8. Example Analysis of Road Rater Deflections: Subgrade Moduli Predictions from No. 1 Deflections and No. 1 Projected Deflections; Graph of No. 1 Deflections versus No. 1 Projected Deflections; and No. 1 Deflections versus Subgrade Moduli.

SUMMARY

The procedures for the evaluation of pavement performance and condition presented in this paper utilize the concepts developed and published in 1978 (14, 15, 23). Since then, these concepts and the associated procedure has been modified and simplified to provide a more workable procedure.

A key to an adequate design of an overlay for any pavement structure is to be able to determine reasonable values for design parameters that represent the condition of the existing pavement. The parameters considered in Kentucky's procedure include the in-place subgrade modulus and the effective thickness of the existing pavement structure at a specified reference modulus of elasticity of the asphaltic concrete. The total thickness of an overlay is equal to the difference between the thickness needed for some future design level (based on traffic volumes and associated equivalent axleloads and the in-place subgrade modulus (CBR)) and the effective thickness of the existing asphaltic concrete layers.

There is a need for continued research in this area as highway maintenance becomes more and more significant. As costs continue to rise, the pressure to adequately assess the condition of existing pavements increases.

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